AMENDMENTS TO THE SPECIFICATION

Please amend the specification as indicated below.

Please amend paragraph **[0003]** as indicated:

[0003] Communications between an ultrasonic transducer mounted or positioned on a movable stylus (such as a ~~moveable~~ movable pen) and other remotely located transducers (for example, transducers fixed at remote positions from the stylus) make it possible to determine the position of the pen and ultimately to reproduce information associated with stylus movement. The digital information associated with the stylus position might be used for drawings, maps, or pictorial illustrations, as well as for e-mail, sending of facsimiles, document creations, document and file creation reproduction (in combination with a word processor), or input devices for computer games, for example.

Please amend paragraph **[0005]** as indicated:

[0005] The main acoustic beam direction of the above mentioned device is perpendicular to the axis of the cylinder on which the piezoelectric film is wrapped. In the case of an ultrasonic pen or stylus, the cylindrical ultrasonic transducer is mounted or positioned on a movable stylus such as a ~~moveable~~ movable pen and other remotely located transducers (for example, transducers fixed at remote positions from the stylus) receive signals emanating from the mounted transducer as the stylus moves, making it possible (via triangulation, for example) to determine

the position of the pen and ultimately to reproduce information associated with stylus movement. The position of the cylindrical film should be slightly higher than the tip of the pen because the height of the cylinder is typically 3-5 millimeters (mm) for a 80 KHz design and doubles for a 40 KHz design. The ultrasonic wave radiates from the center of the cylinder and the center of radiation is several millimeters above the pen tip. When the position of the pen tip is fixed on a point of the writing surface and the angle of pen is varied, the effective position of the cylindrical transducer moves, and false information is transmitted because the system is designed to detect the absolute position of the transducer. Therefore, during writing or using of the pen, a person has to hold the pen at an exact, constant angle in order for the system to work as designed with maximum accuracy. Moreover, such transducers have been typically mounted externally on the pen, which causes additional problems for both the user, who must hold the stylus, and for the signal detection/transmission circuitry. Structures disposed about the outer surface of the stylus in a ring-like manner and placement of the structure at or substantially near the location of the stylus tip ~~interferes~~interfere with the user's ability to adequately grasp or hold the stylus. In addition, such location operates as an obstruction to the user's viewing of the information as it is being written. Accordingly, a need exists to provide an improved transducer apparatus mountable within a stylus for transmitting acoustic signals.

Please amend paragraph **[0006]** as indicated:

[0006] FIG. 1A is a perspective view of a mandrel or holder according to an embodiment of the invention.

Please amend paragraph **[0007]** as indicated:

[0007] FIG. 1B is a perspective view of an embodiment of a multi-segment, cylindrical ultrasonic transducer (MSCUT) according to the invention which uses the holder shown in FIG. 1A.

Please amend paragraph **[0008]** as indicated:

[0008] FIG. 1C is a sectional view of the MSCUT shown in FIG. 1B.

Please amend paragraph **[0011]** as indicated:

[0011] FIG. 2A is a perspective view of a mandrel or holder according to another embodiment of the invention.

Please amend paragraph **[0012]** as indicated:

[0012] FIG. 2B is a perspective view of another embodiment of a MSCUT according to the invention which uses the holder shown in FIG. 2A.

Please amend paragraph **[0013]** as indicated:

[0013] FIG. 2C is a sectional view of the MSCUT shown in FIG. 2B.

Please amend paragraph **[0018]** as indicated:

[0018] FIG. 5B is an enlarged elevational view of a portion of the piezoelectric transducer film shown in FIGS. 1B-1E prior to being formed into a cylinder.

Please amend paragraph **[0019]** as indicated:

[0019] FIG. 5C is an enlarged view of the MSCUT shown in FIGS. 1B-1E.

Please amend paragraph **[0022]** as indicated:

[0022] FIG. 8 is a schematic illustration ~~shown~~showing how acoustic signals are generated and propagate from the MSCUT of the invention.

Please amend paragraph **[0034]** as indicated:

[0034] FIG. 13B is a theoretical plot [[of]] showing the signal strength as a function of frequency for various film-housing spacings.

Please amend paragraph **[0040]** as indicated:

[0040] FIG. 18 is a schematic illustration of an alternate embodiment of a drive circuit according to the invention, as used for driving a single ring electrode cylindrical transducer.

Please amend paragraph **[0041]** as indicated:

[0041] FIG. 19 is a schematic illustration of the drive circuit shown in FIG. 18 according to the invention, as used for driving a multiple ring electrode cylindrical transducer.

Please amend paragraph **[0042]** as indicated:

[0042] FIG. 20 is a schematic representation of a handheld stylus including a transducer, made according to the invention.

Please amend paragraph **[0079]** as indicated:

[0079] As shown in FIG. 1C, the center to center distance d between each pair of electrode segments 161 is about one-half wavelength of the acoustic wave in air, and an excitation voltage V is applied to the segments 161 on outer and interior surfaces 131, 132 of the transducer film 130 such that the phase of the excitation voltage alternates from one segment 161 to another. The voltage V applied to the piezoelectric transducer film 130 by means of electrode segments 161 causes acoustic waves to propagate along the outer and inner surfaces of the transducer 110. As shown in FIG. 1E, the cover 150 includes an inwardly directed flange 153 at the open end 151 thereof, which blocks and, therefore, inhibits the propagation path of the acoustic waves propagating along the outer surface of the transducer 110. In this manner, only the acoustic waves 170 propagating along the inner surface of the transducer 110 ~~is~~are emitted from the MSCUT structure 100.

Please amend paragraph **[0080]** as indicated:

[0080] FIGS. 2A-2D collectively illustrate another embodiment of a MSCUT structure according to the present invention, denoted by numeral 100'. In this embodiment, the multi-segment, cylindrical transducer 110' of the MSCUT structure

100' has a solid holder 120', which is constructed so that acoustic waves propagating along the inner surface of the transducer 110' are blocked (i.e., not used). Further, the cover 150' of the MSCUT structure 100' has an open end 151', which is constructed to allow acoustic waves 170' propagating along the outer surface of the transducer 110' to be emitted from the MSCUT structure 100'.

Please amend paragraph **[0081]** as indicated:

[0081] It should be understood, that the MSCUT ~~the~~ structures 100, 100' depicted in FIGS. 1A-1E and 2A-2D may also be utilized as receivers, wherein an incident acoustic wave in the axial direction induces a voltage on the segmented electrodes 160. Since many electrode segments 161 are connected in parallel, the voltages generated thereby may be substantially the same and connected in parallel, the output current increases with increasing numbers N of electrode segments 161.

Please amend paragraph **[0085]** as indicated:

[0085] FIG. 4 is a schematic illustration of a diverging acoustic beam B emanating from an output end 251 of an acoustic transducer 250. Greater beam divergence $\Delta\theta v$ is manifested in the X direction than in the Y direction from a rectangular aperture 252 at the output end 251 of the transducer 250. This is because the vertical dimension of the aperture 252 is relatively large, such that beam divergence is less in the vertical direction while the horizontal dimension of the aperture 252 is relatively smaller, such that beam divergence $\Delta\theta v$ is larger in

the horizontal direction. In the case of either a circular exit area with a small diameter or ring shaped exit area with the pen tip at the center, the small size of <u>the</u> exit area makes a circular beam profile with high divergence.

Please amend paragraph **[0088]** as indicated:

[0088] FIG. 5C is <u>an</u> enlarged view of the transducer 110 showing the piezoelectric transducer film 130 cylindrically wrapped around the holder 120. Once wrapped, the ends of the piezoelectric transducer film 130 are secured to one another using any suitable means, including without limitation, an adhesive, and preferably, by ultrasonically welding the ends to one another. Note that the periodicity of each electrode segment 161 is chosen to be about one-half wavelength.

Please amend paragraph **[0089]** as indicated:

[0089] Referring to FIGS. 5B and 5C, the excitation voltage V is applied to the electrode segments 161 in a manner wherein the phase of the voltage applied to each electrode segment 161 alternates from one segment 161 to another. This causes the transducer 110 to produce vibration phases that are opposite to one another, as shown in FIG. 6. The vibration of the transducer film 130 induces pressure variation in the transducer 110, which varies along the longitudinal direction of the transducer 110. When the selected excitation voltage with frequency Vs/2f (where Vs is the excitation voltage and f is the frequency) is equal to the $\lambda/2$

periodicity, (i.e., one-half wavelength), ~~an~~ acoustic waves are generated by the transducer 110. The acoustic waves propagate along the longitudinal axis of the transducer 110 in both directions, as shown in the sectional view of FIG. 7.

Please amend paragraph **[0094]** as indicated:

[0094] FIG. 10D shows another embodiment of a stylus 400' utilizing ~~an~~ a cylindrical transducer according to another embodiment of the invention, denoted by numeral 510'. The stylus 400' comprises a housing 410' defining an internal bore 420' having opening 420a' for receiving a drawing implement 430' having a drawing tip 442' extending only a slight distance Δx from the plane of the opening 420a'. The transducer 510' comprises a cylindrical piezoelectric PVDF transducer film 530' disposed about a spool-shape mandrel or holder 520' located within the housing 410' of the stylus 400'. The holder 520' includes an orifice 526' that extends the length of the holder 520', and which is sized to ~~accommodated~~ accommodate the drawing implement 430' therethrough. The outer and inner surfaces 531', 532' of the transducer film 530' each include a ring-shape electrode layer 561'.

Please amend paragraph **[0096]** as indicated:

[0096] Both transducer films 730, 730' are electrically connected in parallel, however, the relation between film polarity and electric field direction ~~are~~ is selected such that the displacement of one film is in the direction opposite to that of the other film. In other words, when one film shrinks in vibration, causing its diameter to

decrease, the other film expands in vibration, causing its[[,]] diameter to increase. An air gap g defines the space between the two transducer films 730, 730', the air between the films 730, 730' being effectively driven in the axial direction. The ring widths w of the electrode layers 761, 761' on the corresponding transducer films 730, 730' are about equal or less than one-half wavelength.

Please amend paragraph **[0097]** as indicated:

[0097] FIG. 11D shows the stylus 600 and concentric double film transducer structure 700 of FIGS. 11A-11C having a reflector 725 mounted at the end of the transducer structure 700 to reflect the acoustic wave B back in the direction of acoustic wave A, so that both may be used effectively. By this structure, both advantages of a ~~concentrical~~<u>concentric</u> film structure and an in-phase addition of the reflected wave are combined. Note that the ring width of the electrode layers 761 is about one-quarter wavelength or less in this embodiment.

Please amend paragraph **[00100]** as indicated:

[00100] In order to enhance the axial acoustic wave excitation, there is shown in FIG. 15 an embodiment of a sequentially driven multiple ring electrode cylindrical transducer 1110 made according to the principles of the invention. The transducer 1110 comprises a cylindrical piezoelectric transducer film 1130 made from a PVDF material, for example, having multiple ring electrodes 1161 disposed on the outer surface 1131 thereof, and a common ground on the inner surface 1132 thereof. The

operation of such device is as follows. First, one of the ring electrodes 1161 on the outer surface 1131 of the film 1130 is driven. Second, an adjacent second one of the ring electrodes 1161, located in the direction of and, therefore, in front of the propagating acoustic wave, is driven with a time lag, relative to the first driven electrode 1161. The time lag is given by T=d/Vs where d is the center to center distance of the two adjacent ring electrodes 1161 and Vs is the propagation velocity in air. The third, fourth, fifth, etc . . . electrodes 1161 are then sequentially driven. During the time T, the acoustic wave proceeds by distance d and the relationship between the drive voltage and the excited acoustic wave, are the same for each electrode 1161. The one-cycle-drive is then sequentially applied to the next electrode pair and the driven voltage moves with the same speed as the wave propagates. Thus, a single cycle acoustic wave increases in strength after the aforementioned series of excitations. Note here that the film cylinder has its own resonance and "one cycle drive" means, at a first half cycle a displacement is given to the film and at <u>a</u> next half cycle, the film displaces to the opposite direction (kick back) with its own resonance behavior, and at this time the drive voltage provides an opposite sign of voltage compared with the initial half cycle, and this forced drive and its own displacement are in an in-phase condition. Therefore, the displacement of the initial half cycle is very small but, the next half cycle is much larger and this larger displacement is used as the signal. To aid in understanding this, consider <u>the</u> following analogy involving the swinging of a child swing. At first you push the swing

with a small force, which does not cause much of a swing action, but when the swing comes back, you pull it, and then, the swing action becomes larger the second time.

Please amend paragraph **[00104]** as indicated:

[00104] The decay rate depends on the loss associated with the capacitor. For a PVDF transducer film, the film is lossive with tan delta=0.1. In order to reduce the effective loss, a high quality capactior C shown in FIG. 19 is connected in parallel with the inductor 1302. The capacitor C is not switched. In this way, a very strong, single cycle wave is excited and propagates in the axial direction. The transducer of the invention mounted in the interior of the stylus housing generates an axial waveform, which propagates along the bore of the housing, until it reaches the housing opening. The opening is substantially co-located with the tip region of the drawing implement so that the ultrasound signal exiting from the opening reflects off the location of the drawing implement on the pen or stylus independent of the tilt angle of the stylus.

Please amend paragraph **[00109]** as indicated:

[00109] Referring now to FIG. 24A, there is shown an embodiment of a flat ultrasonic transducer according to the invention, denoted by numeral 2040. The flat ultrasonic transducer (FUT) 2040 comprises a thin, flat, diaphragm 2044 and a thin, flat, piezoelectric transducer film 2042 adhesively bonded to the diaphragm 2044.

The diaphragm 2044 may comprise, without limitation, a metal, such as Aluminum (Al), and may be circular (as shown), square or rectangular in plan view. The Al-based diaphragm 2044 may have a thickness of about 0.1 mm-0.8 mm, depending on the diameter. The transducer material 2042 may comprise, without limitation, a piezoelectric ceramic, such as lead-zirconate-titanate (PZT), and may be circular (as shown), square or rectangular in plan view. The transducer 2042 may be ~~The~~ a PZT-based transducer film 2042 and may have a thickness of about 0.1 mm-0.5 mm. The diameter of the diaphragm 2044 in this embodiment is larger than the diameter of the transducer material 2042. However, as shown in FIG. 24B, the transducer material 2042 may have a diameter which is substantially the same as the diameter of the diaphragm 2044. In addition, the FUT 2040 may be supported in an annular mounting member 2046 made from an acoustically lossy/flexible material. The mounting member 2046 supports front and back sides 2040a, 2040b of the FUT 2040.

Please amend paragraph **[00113]** as indicated:

[00113] The central bore 2226 has a relatively much small diameter d (FIG. 25B) as compared to the diameter of the vibrating area~~are~~ of the transducer material 2042 and is substantially coaxial with the FUT 2040. As shown in FIG. 25B-25D, the portions of the bore 2226 not occupied by the implement 2250, switch 2254, and stopper 2255, operate as a waveguide for the propagating acoustic wave or

signal output generated from the FUT 2040. The acoustic waves or signal generated by the FUT 2040 propagates through the narrow gap G at the front of the vibrating diaphragm 2044 and is guided down the central waveguide bore 2226. The engagement between the peripheral edge of the FUT 2040 and the inner side surface 2228 of the housing body portion 2222 creates a seal, which forces the acoustic waves to propagate through the waveguide bore 2226.

Please amend paragraph **[00124]** as indicated:

[00124] FIGS. 31A and 31B show partial views of two embodiments of a handheld stylus 2700, 2700' having multiple FUTs 2040_1, 2040_2, 2040_3, 2040_4, . . . , disposed within a stylus housing 2720, 2720' and aligned toward the axial direction of the stylus 2700, 2700'. The ~~embodiment~~embodiments differ in how the FUTs 2040_1, 2040_2, 2040_3, 2040_4, . . . , are driven with voltage phases to generate an acoustic signal S propagating along bore 2726, 2726'. As shown in FIGS. 31A and 31B the center-to-center distance D1 between adjacent FUTs (e.g. between 2040_1 and 2040_2, 2040_3, 2040_4, . . .) is one-half wavelength of the propagation medium (e.g. air). In the embodiment of FIG. 31A, the FUTs 2040_1, 2040_2, 2040_3, 2040_4, . . . , are driven by an AC drive source 2772, using electrodes disposed on sides e_1 of the transducer materials 2040_1, 2040_2, 2040_3, 2040_4, . . . , which are commonly connected to positive terminal V_1, and electrodes disposed on sides e_2 of the transducer films 2040_1, 2040_2, 2040_3, 2040_4, . . . , which are commonly connected

to ground terminal Vg. The polarization of the FUTs 2040_1, 2040_2, 2040_3, 2040_4, . . . , alternate in the opposite direction to enable constructive interference of the resultant acoustic signals propagating along waveguide bore 2726 when driven by common drive source 2772.

Please amend paragraph **[00127]** as indicated:

[00127] FIG. 32B shows yet another embodiment <u>of</u> a handheld stylus 2900 (with the connection to drive source not shown) that is similar to the embodiment shown in FIG. 29A but including multiple FUTs 2040_1, 2040_2, 2040_3, 2040_4, disposed (within the stylus housing 2920) parallel with the longitudinal axis LA of the stylus housing 2920 and transmitting acoustic signals S1, S2 down respective waveguide bores 2926_1, 2926_2 which exit at an emitting opening of the stylus housing 2920. Note that <u>in</u> the embodiments shown in FIGS. 31A-B and 32A-B, the drive circuit driven FUTs generate an acoustic signal that linearly increases with time (i.e. the acoustic signal output increases with increasing drive cycles). Alternatively, according to an additional aspect of the invention, each FUT may be driven by a driver having a time delay of drive voltage, corresponding to the propagation time of the acoustic signal output from a given FUT to the next adjacent FUT position along the waveguide bore or narrow gap, so that the phase relationship between the axially propagating acoustic wave from each FUT and the waveform of the drive voltage is the same for all FUTs. This enables the bandwidth of the stylus to be

quite broad, while also enabling the amplitude of the excited acoustic wave to be, in effect, multiplied by each of the multiple FUTs axially aligned with and appropriately spaced apart from one another, thereby providing a very strong acoustic signal after only a few cycles.